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Performance investigation of an operational digital microwave link located over Indian eastern sector

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Abstract The performance of a microwave digital communication link located in the Indian eastern sector has been investigated The results on the distribution of signal level and bit error rate have been presented The bit error rate increases considerably when the signal level is equal or less than - 70 dBm for considerable percentage of time The system is equipped with the vertical space diversity It has been found that the diversity channel serves the purpose when the signal level is equal or more than - 75 dBm in the regular channel The other remedial techniques including antenna tilting and path inclination have also been discussed to counter the multipath fading in order to increase the signal level and decrease bit error rate

Keywords Communication link, signal level, bit error rate, multipath fading, diversity

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The performance of digital communication link operating in microwave frequency band is affected by clear air phenomena. In clear air situations, multipath fading and scintillation fading are the most dominant phenomena which affect the propagation [1]. There is dearth of data on microwave amplitude variations which are achievable with digital microwave communication links in India. Some results on digital communication link located at Western Ghat has been reported by Prasad *et al* [12]. The performance of a digital communication link having data speed 140 MBPS located in Indian eastern sector is reported for the first time. The probability distribution of field strength depicts that for 90% of the time in the month of November, field strength exceeds – 70 dBm in regular channel and for 97% of time, the field strength exceeds – 70 dBm in the diversity channel. The performance of the link has been found to be affected severely due to multipath fading. In order to counter the multipath fading, some remedial measures such as frequency diversity, space diversity *etc.* are usually used [3, 4]. The operating link is equipped with vertically space diversity. It has been investigated that the diversity channel serves the purpose when the signal level is equal or more than –75 dBm in the regular channel. It has been found that the signal level is around ~ – 70 dBm in the diversity channel when the simultaneous signal level is around – 75 dBm in the regular channel. The other remedial techniques *viz*., antenna and path inclination [5-7] have been discussed to counter the multipath fading occurring in the said link.

The measurements on amplitude variation were carried out by using a digital microwave communication link during November, 1995. The detail characteristics of the link are the following.

Transmitted power	:	32 dBm
Data speed	:	140 MB per sec
Transmitting antenna gain	:	47 dB
Receiving antenna gain	:	47 dB
Main antenna height	:	90m
Space diversity antenna height	:	80m
Frequent range	:	7725 MHz to 8275 MHz
Band Width	:	550 MHz
Fade margin	:	30 dB
Free space loss	:	143 dB

The radio meteorological parameters were derived from the upper air observations. Such observations were taken from the India Meteorological Department where two flights are flown, one at 0000 GMT and the other at 1200 GMT.

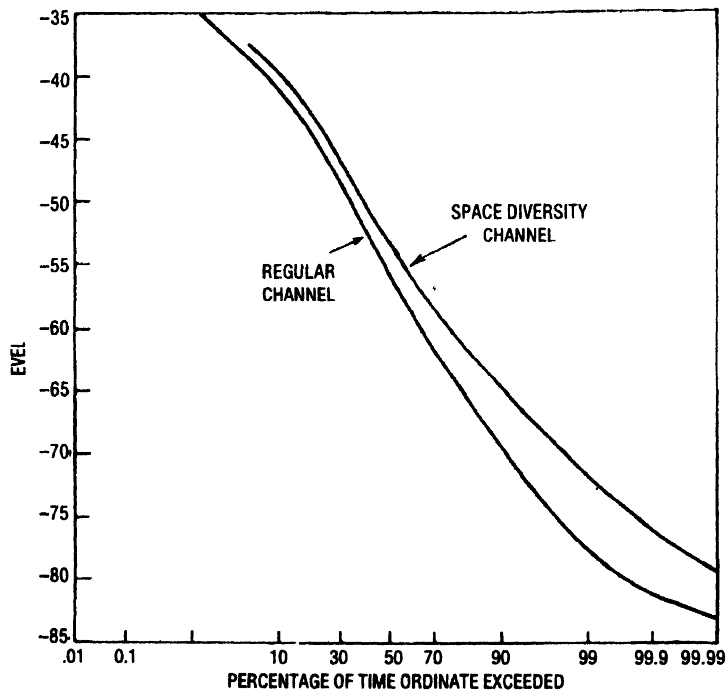

Figure 1. Probability distribution of signal levels measured over two channels.

The performance of a communication link has been investigated. The measurements of signal level and bit error rate (BER) were taken during the period of November, 1995. The terrestrial link is utilised for data transmission. The BER 10^{-6} is acceptable for data transmission. But, if BER > 10^{-6} then the real problem arises for data transmission work. The problem in data transmission cannot be afforded in such type of operational communication link. In order to have BER ~ 10^{-6}, the signal level is to be of the order of – 70 dBm. The probability distributions of the signal level received in two channels are shown in Figure 1. The simultaneous measurements of signal level and bit error rate during the problematic period are presented in Table 1.

Table 1. Simultaneous observations on signal levels and bit error rate during problematic period

Signal level dBm	Bit error rate
– 75	2×10^{-3}
– 73	5×10^{-4}
– 72.5	5×10^{-5}
71	10^{-5}
– 70	10^{-6}
– 69	2×10^{-9}

Simultaneous recordings were done in regular channel and in another channel which is equipped with the vertical space diversity. It is found that for considerable percentage of time, the signal level is less than – 70 dBm. In regular channel, it is seen that for 90% of the time the signal level exceeds – 70 dBm while in space diversity channel for 97% of the time the signal level exceeds – 70 dBm. It is important to note here though space diversity is found to work more effectively when the signal level is less than – 71 dBm. But, the threshold requirement of the signal level is around and upto – 70 dBm. It is observed that even a loss of signal level of ~ 2 dB *i.e.*, when the signal level is of the order of – 73 dBm, the bit error rate (BER) increases very rapidly. The corresponding bit error rate (BER) is ~ 10^{-5}. Similarly, it is seen that the BER is around ~ 10^{-4} when the signal level is – 74 dBm and the BER is ~ 10^{-3} when the signal level is – 76 dBm. The propagation path consists of a lot of vegetation including trees, cultivated land *etc*. The river Ganges is about ~ 800 m from the receiving end which is a source of water vapour over the propagation path. The water vapour concentration over the surface around this region is ~ 15 gm/m^3 during November while the water vapour concentration is around ~ 9 gm/m^3 at 250 m. The presence of water vapour causes a change in the environment. Such change causes change in the radio refractivity structure. The average values of temperature, humidity and pressure are ~ 23°C and 24°C ; 74% and 67% and 1014 mb and 1010 mb during 0000 GMT and 1200 GMT around the propagation site. The total rainfall during the period of propagation experiment is 35 mm. The radio rays coming from different propagation modes such as ground reflection, direct rays, scattering and reflection from the atmospheric irregularities *etc.* interfere among each other. Such interference causes fading and eventually resulting in the fall of signal levels. Radioclimatological characteristics prevailing over this region is presented in Table 2.

Table 2. Radioclimatological characteristics over the propagation site.

Month	Refractivity gradient 0000 GMT	Refractivity gradient 1200 GMT	Sub refraction occurrence % 0000 GMT	Sub refraction occurrence % 1200 GMT	duct occurrence % 0000 GMT	duct occurrence % 1200 GMT
Nov	- 80 N/km	- 70 N/km	15	30	13	6

The results on mean initial refractivity gradient, subrefraction occurrence probability and duct occurrence probability between surface and 250 m have been derived by using upper air observations pertaining to the period 1968-79 [8]. Such data was obtained from the India Meteorological Department. It is seen from the results on radio meteorological parameters that mean refractivity gradient over this region during November is – 70 N/km which is quite high. Similarly, it is seen that the duct occurrence probability during November at 0000 GMT and 1200 GMT is 13% and 6%. Such occurrence percentage is quite significant and signifies that the degree of stratification is high. Multipath fading is quite dominant under such atmospheric stratification. The total loss derived by using the received power (–70 dBm) has been found to be 186 dB. The total path loss has been found to be around 156 dB when the received signal level is –40 dBm. Such signal level which is considered to be quite high exceeds for 9% of time during November. The total antenna gain in the present system is 93 dB. But such antenna gain is due to plane wave. There is some loss in the effective antenna gain due to aperture to medium coupling loss. The loss under free space condition is found to be around 143 dB. The extra loss with respect to free space loss when the signal level is –70 dBm is (196 dB – 143 dB=) 53 dB. Such loss is due to interferences from ground reflections and contributions from the atmospheric irregularities with direct rays at the receiving beam. The extra loss when the signal level is quite high ~ – 30 dBm with reference to free space loss is around (156 dB – 143 dB =) 13 dB. The extra loss ~ 13 dB is of low order. Such low loss indicates that the interferences from ground reflection and contribution from atmospheric irregularities are quite significant. In order to reduce the extra losses, the two techniques such as antenna tilting and path inclination are to be employed. In case of antenna tilting, the contribution from the ground reflection is minimised so that maximum contribution is obtained from direct ray thus reducing the multipath funding. In case of path inclination, the contributions of reflections from the atmospheric irregularities are made minimised. Maximum contribution is achieved from direct ray. But, in case of path inclination some hill top or high rise building around the surrounding is required. The antenna tilting is the most suitable technique available in this case to counter the multipath fading.

An attempt has been made to provide the results on the distribution of signal levels over the eastern sector deduced from the measurements of a microwave digital operational link. The performance deterioration of the link in relation to multipath fading has been identified. Some remedial measures to counter multipath fading and loss of signal level and increase bit error rate have been provided.

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